Check List **5**(2): 210–215, 2009.
ISSN: 1809-127X

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Four new additions to the marine flora of Fernando de Noronha Archipelago, Tropical western South Atlantic Ocean

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Fernando de Noronha Archipelago is an isolated group of volcanic islands located in the tropical western South Atlantic Ocean, 345 km off the north-eastern coast of Brazil. It consists of one large island and 19 small adjacent islets totalling 26 km^2 that represent the peaks of the Mid-Atlantic Ridge (Maida and Ferreira 1997).

The macroalgae of the archipelago were first studied in the nineteenth century (Dickie 1874; Hemsley 1885; Murray 1891), and since then, occasional surveys have increased the knowledge of the diversity of the local species of benthic seaweed. Currently, the marine flora of Fernando de Noronha includes 135 taxa, represented by 56 species of Chlorophyta, 51 Rhodophyta and 28 Ochrophyta (Oliveira and Ugadim 1974; Eston et al. 1986; Szèchy et al. 1989; Pedrini et al. 1992).

As part of a seaweed-herbivore interaction investigation accomplished in 2007, surveys were conducted to identify the benthic macroalgae community in two sites of the main island. As a result, herein are reported the occurrence of four species, *Blidingia marginata* (J. Agardh) P. J .L. Dangeard ex Bliding, *Halimeda gracilis* (Harvey) ex J. Agardh, *Sargassum hystrix* var. *buxifolium* (Chauvin) J. Agardh and *Dictyota caribaea* Höring & Schnetter, which represent additions to the marine flora of Fernando de Noronha Archipelago and also extend the geographical distribution of those species in the tropical western South Atlantic Ocean.

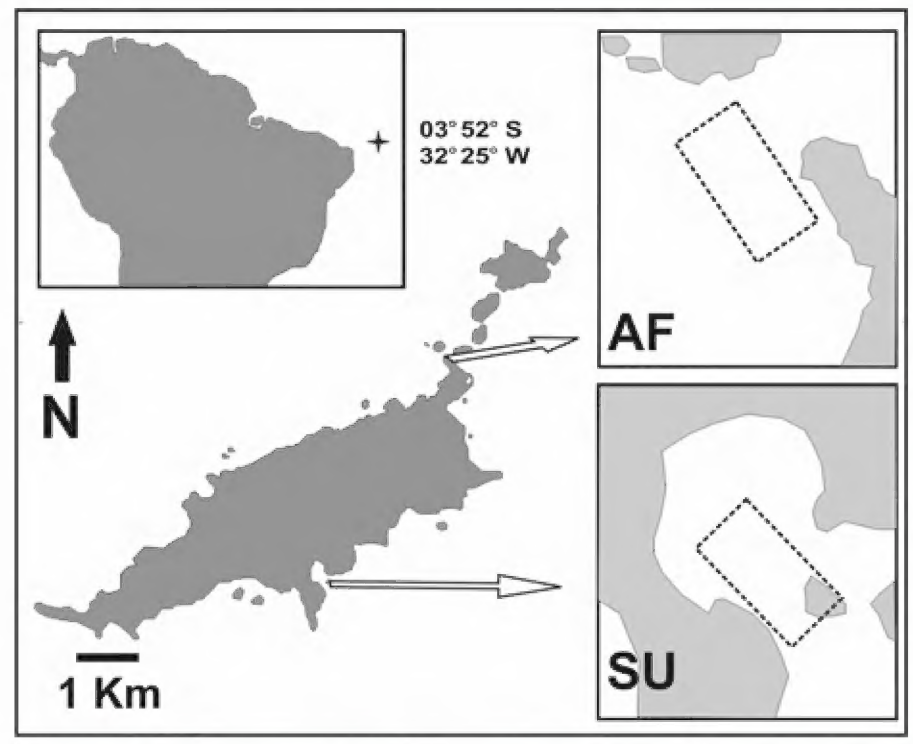

Figure 1. Geographical localization of Fernando de Noronha Archipelago in the western South Atlantic Ocean and the two study sites in the main island, Air France (AF) and Sueste (S). The rectangles indicate the location of the areas of approximately 40,000 m^2 where the 50 m^2 quadrants were randomly sampled.

The archipelago is located at 3°52'00" S, 32°25'00" W, and is under the influence of the northern branch of the South Equatorial Current and the Equator Surface Current (Tchernia 1980). Mean water temperature is 26° C and mean salinity is 36 PSU. The leeward seascape of the archipelago is mainly composed of descending slopes with large scattered boulders and patch reefs, whereas the windward side is characterized by extensive algal-vermetid ridges along rocky shorelines (Maida and Ferreira 1997).

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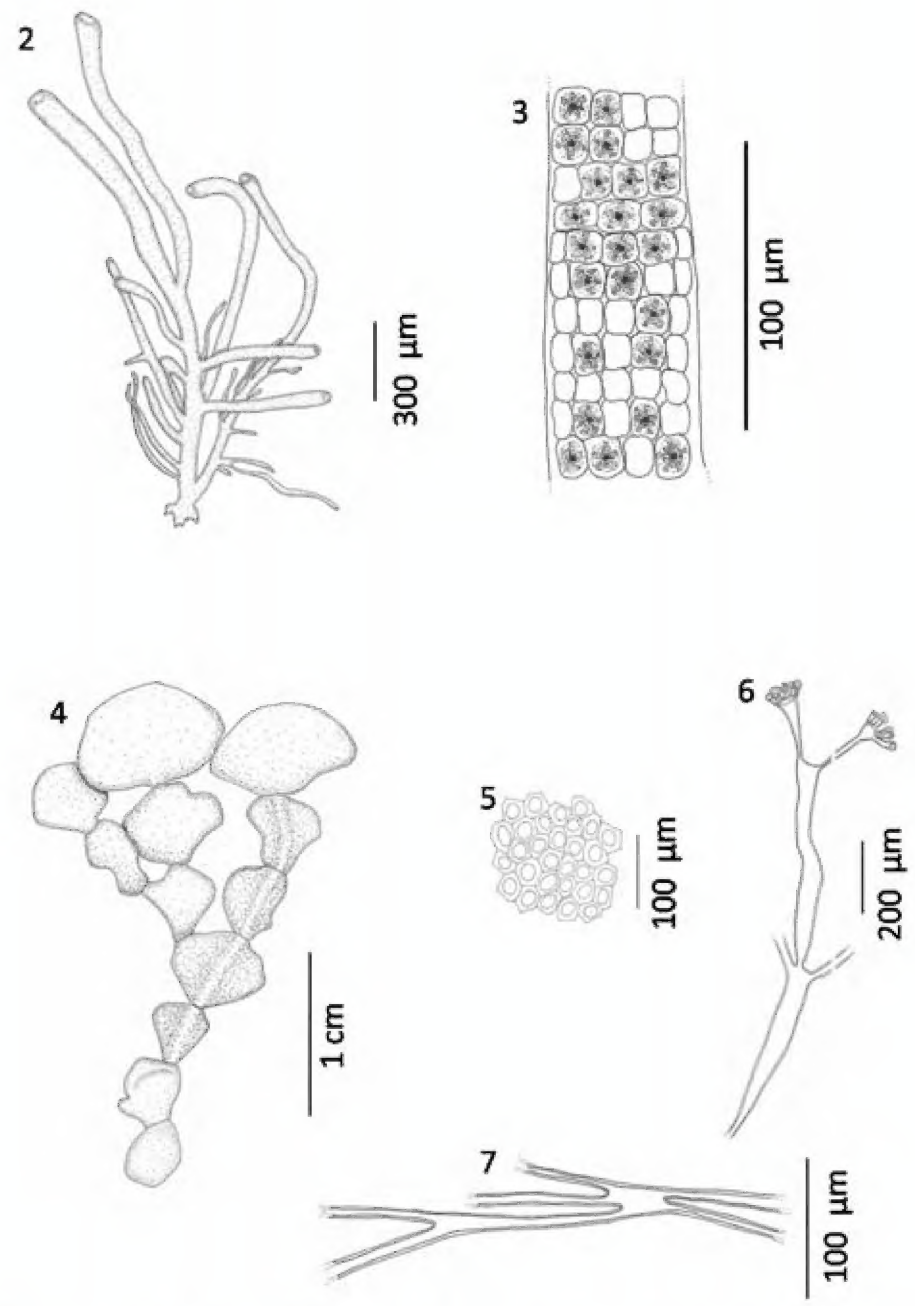
During three consecutive days of October 2007, seaweed specimens were randomly collected by hand during snorkelling dives in quadrants of 50 m^2 randomly distributed in areas of approximately 40,000 m^2 in two sites of the main island (Figure 1): Air France (AF), located in the extreme north-western of the main island leeside, whose bottom is composed of a mosaic of gravel, reef and sand in depths ranging from 1 to 12 m, and Sueste (S), a protected bay in the windward side characterized by sand bottom and dispersed seaweed and reef banks in depths of 2 to 6 m. Collected specimens were cleaned from sediment and fixed in a 4% formalin-seawater solution. Species identification followed Taylor (1960), Joly et al. (1968), Ugadim (1973), Littler & Littler (2000), Bandeira-Perosa et al. (2004) and Brodie et al. (2007), and geographic distributions followed Guiry and Guiry (2008). Specimens were deposited in the Herbarium of *Departamento de Botânica, Instituto de Biologia, Universidade Federal do Rio de Janeiro*. Diagnostic features of the species are presented bellow and their geographical ranges in western Atlantic waters are summarized in Appendix 1.

Blidingia marginata is a small erect, and filamentous light green algae up to 2.5 mm long that is fixed to the substrate by a delicate discoid holdfast (Figure 2). Its tubular filaments are hollow in advanced developmental phases, with the distal sections ranging 35-108 Ām in diameter and 18-72 Ām in proximal sections. Lateral branches lead to the lower parts of thallus and are similar in structure to its principal axis. Cells in longitudinal rows, quadrate, ranging from 9 to 13 Ām of diameter, and have a single stellate chloroplast with a single pyrenoid (Figure 3, Voucher RFA 34335).

Studied samples were collected on fronds of *Ceramium flaccidum* (Kützing) Ardissone in a wave-exposed site of Sueste. Fertile specimens were not observed. The following synonyms are included as *Blidingia marginata* (J. Agardh) P. J. L. Dangeard ex Bliding: *Blidingia marginata* (J. Agardh) P. J. L. Dangeard, *Enteromorpha marginata* J. Agardh, *Enteromorpha marginata* var. *longior* Kützing, *Enteromorpha micrococca* Kützing. In the western north Atlantic, the species is reported to North America and the Caribbean Islands. In South America it is reported to Argentina and the Brazilian states of Bahia, Rio de Janeiro, São Paulo and Rio Grande do Sul (see Appendix 1 for details and references).



Figures 2 to 7: (**2**) Habit of thallus of *Blidingia marginata*; (**3**) Surface view of the quadrtic cells in longitudinal rows; (**4**) Detail of *Halimeda gracilis*; (**5**) Surface view of the utricule; (**6**) Detail of primary and secondary utricules and medullary filaments; (**7**) Nodal fusion of medullary filaments (see text for detailed descriptions).

Halimeda gracilis is a light green, erect algae with articulated fronds up to 27 mm long, composed by flattened disc-shaped segments, attachment to unconsolidated bottoms by a single rhizoidal system. The flattened calcified segments of the frond have a rigid texture, are disc-shaped in the distal portion and semi-cylindrical in the proximal section, ranging from 3-5 mm long and 2-8 mm wide (Figure 4). The thallus is internally

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composed of cortex and medulla. In superficial view, the cortex is composed of primary polygonal utricles ranging 26-43 Ām of diameter (Figure 5). In longitudinal section, is observed two, rarely three layer of utricles. The primary utricles are cuneate, up to 32 Ām long, and linked to the clavate secondary utricles that are up to 68 Ām long, and connected to medullar filaments that are fused at the node region (Figures 6 and 7, Voucher RFA 34334).

The collected plants were found on sand bottom close to *Caulerpa racemosa* (Forsskål) J. Agardh at 3 m depth in Sueste. Fertile specimens were not observed. In western Atlantic waters the species is recorded in the Caribbean Islands and Central America. It was first reported to Brazil by Taylor (1960), although no reference of the site of collection is provided. It is recorded in the Brazilian states of Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Sergipe, Bahia, Espírito Santo, and Rio de Janeiro (Appendix 1).

Sargassum hystrix* var. *buxifolium is a light to dark brown, erect plant with leathery fronds up to 30 mm long, fixed to the bottom by a disc-shaped holdfast with up to 2 mm diameter. The thallus are composed of few oblong leaves with a central midrib, asymmetric base, with undulated to smooth margins up to 10 mm wide that are eventually bifurcated (Figure 8). The criptostoma range 200-260 Ām in diameter and are profusely dispersed along the leaf extension in both sides of the midrib. In transversal view one layer of cortical cells, 4 to 16 layers of medullar cells in the central midrib (Figures 9 to 11). Fertile specimens were not observed (Voucher RFA 34332).

All specimens collected were sterile and were found intermingled with *Dictyopteris* sp. in Sueste. In the western Atlantic this variety is reported to the Caribbean Islands. Pedrini et al. (1992) first recorded *Sargassum hystrix* J. Agardh in Fernando de Noronha, but made no reference to the *buxifolium* variety. Taylor (1960) reports this variety to the Brazilian coast, but did not specify the site of collection, and Figueiredo (2006) reposts to Abrolhos Archipelago at Bahia state (Table 1).

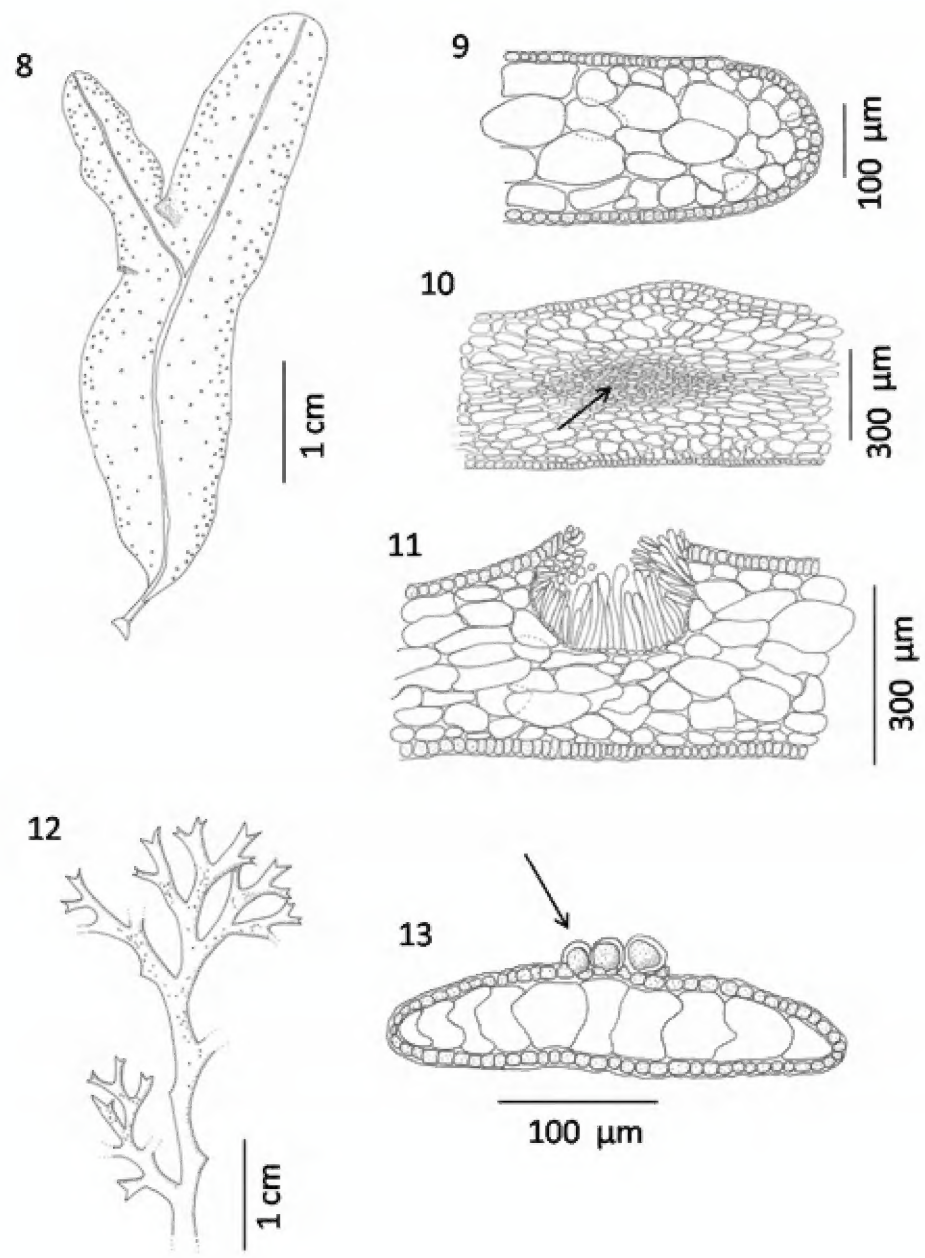

Figura 8 to 13: (**8**) Detail of a leaf of *Sargassum hystrix* var. *buxifolium*; (**9**) Transversal section of the lateral region of the leaf; (**10**) Transversal section of the midrib region (arrow) of the leaf; (**11**) Transversal section of the leaf in the cryptostoma region; (**12**) Detail of apical branch of *Dictyota caribaea*; (**13**) Transversal section of the thallus with the sporangial sore (arrow).

Dictyota caribaea is an erect olive-brown algae with strap-shaped fronds that measured up to 32 mm long in the studied area. The fronds have unequal dichotomic divisions that range 1-2 mm wide, 90-140 Ām thickness and non-constricted branches with sharp apexes (Figure 12). The thallus is internally composed of cortex and medulla. In transversal view, medullar cells in one layer, 53-93 Ām high and 16-83 Ām wide; cortical cells with 16-27 Ām high and 13-33 Ām wide Collected specimens were fertile and bore several sporangial sore that were randomly distributed in the apex portion without paraphises. Sporangium ranged from 30-50 Ām diameter (Figure 13, Voucher RFA 34333).

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ISSN: 1809-127X

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Diagnostic features that distinguishes *D. caribaea* are the sharp apexes, the sporangial sore without paraphises and the non-constricted inter-nodes (Taylor 1960; Littler and Littler 2000). This species were observed growing together with *Canistrocarpus cervicornis* (Kützing) De Paula and De Clerck in wave-exposed sites. In western Atlantic waters this species is known for North America and the Caribbean Islands. It was first recorded in Brazil as *Dictyota indica* Sonder ex Kützing in the state of Rio de Janeiro by Taylor (1931) (Appendix 1).

The observations of these four species increases to 139 the number of seaweeds recorded in Fernando de Noronha (Dickie 1874; Hemsley 1885; Murray 1891; Oliveira and Ugadim 1974; Eston et al. 1986; Szèchy et al. 1989; Pedrini et al. 1992), and demonstrate the importance of detailed fine-scale surveys to enhance the current knowledge of the macroalgae flora in the archipelago and also in the western South Atlantic region. The occurrences of these algae species attest the tropical feature of the marine flora of Fernando de Noronha and demonstrate the influence of the South Equatorial Current from the Caribbean Sea in this part of the tropical Atlantic Ocean.

Acknowledgements
The authors are grateful to the Brazilian Research Council (CNPq) for financial support (Process # 474944/2006-9).

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ISSN: 1809-127X

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Received October 2008
Accepted April 2009
Published online May 2009

Appendix 1. Summary of the occurrence records of *Blidingia marginata*, *Halimeda gracilis*, *Sargassum hystrix* var. *buxifolium*, and *Dictyota caribaea* in the western Atlantic Ocean.
Atlantic Ocean.

Species	Distribution in western Atlantic waters
Blidingia marginata (J. Agardh) P.J.L. Dangeard ex Bliding	**North America:** Florida (Littler et al. 2008), Georgia and North Carolina (Schneider and Searles 1991); **Caribbean Islands:** Cuba (Suárez 2005); **Brazil:** Bahia (Nunes 1998), Rio de Janeiro (Mitchell et al. 1979), São Paulo (Ugadim 1973), Rio Grande do Sul (Coutinho and Seeliger 1984); **South America:** Argentina (Boraso de Zaixso 2004); Urugay (Taylor 1939)

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Species	Distribution in western Atlantic waters
Halimeda gracilis (Harvey) ex J. Agardh	**Central America:** Panama (Wysor and Kooistra 2003); (Kooistra and Verbruggen 2005); **Caribbean Islands:** Caribbean (Littler and Littler 2000), Cuba (Suárez 2005), Barbados, Jamaica, Virgin Islands (Taylor, 1960); Porto Rico (Taylor 1960; Ballantine 1982); **Brazil:** Taylor (1960) (no location), Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Sergipe, Bahia, Espírito Santo, Rio de Janeiro (Bandeira-Pedrosa et al. 2004), Bahia, Espírito Santo (Yoneshigue-Valentin et al. 2006), Ceará (Ferreira-Correia and Pinheiro-Vieira 1969), Pernambuco (Ugadim and Pereira 1978), Rio de Janeiro (Joly et al. 1968; Yoneshigue-Valentin et al. 2006).
Sargassum hystrix var. *buxifolium* (Chauvin) J. Agardh	**North America:** Florida (Taylor 1960), Massachusetts (Taylor 1957), Mexico (Taylor 1960); **Central America:** Costa Rica (Taylor 1960); **Caribbean Islands:** Caribbean (Littler and Littler 2000), Bahamas, Cuba, Barbados, Puerto Rico, Jamaica, Lesser Antilles, Virgin Islands (Taylor 1960, Taylor 1969), Trinidad & Tobago (Duncan and Lee Lum 2006); **Brazil:** Taylor (1960) (no location), Bahia (Figueiredo 2006).
Dictyota caribaea Höring and Schnetter	**North America:** Florida (Littler et al. 2008); **Caribbean Islands:** Caribbean (Littler and Littler 2000), Cuba (Cabrera et al. 2004, Suárez 2005); **Brazil:** Rio de Janeiro as *Dictyota indica* Sonder ex Kützing (Taylor 1931).